



FUGRO



Seawatch Wind  
LiDAR Buoy

Fugro Norway AS

# SEAWATCH - Buoys



## SEAWATCH® Buoy / SEAWATCH Tobis buoy

The first buoy produced by formerly OCEANOR, in the 80s called Tobis



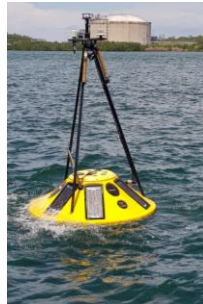
## SEAWATCH® Wavescan buoy

Designed and trademark bought from Seatex (today Kongsberg Seatex), and developed further during the 90s and upgraded design in 2015



## SEAWATCH® Mini II

Second version of our smallest buoy, wave measurement buoy



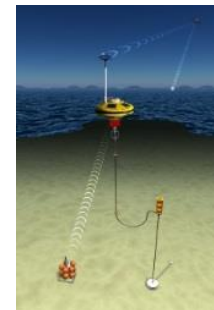
## SEAWATCH® Midi Buoy

Nearshore measurement buoy, water quality



## SEAWATCH® Wind Lidar Buoy

The latest buoys, specialized for Offshore wind farm measurement, built on the wavescan platform, autonomous modular power system (13 months)



## SEAWATCH® Deep Sea Module

Subsea platform for deep sea monitoring, tsunami warning, environmental monitoring

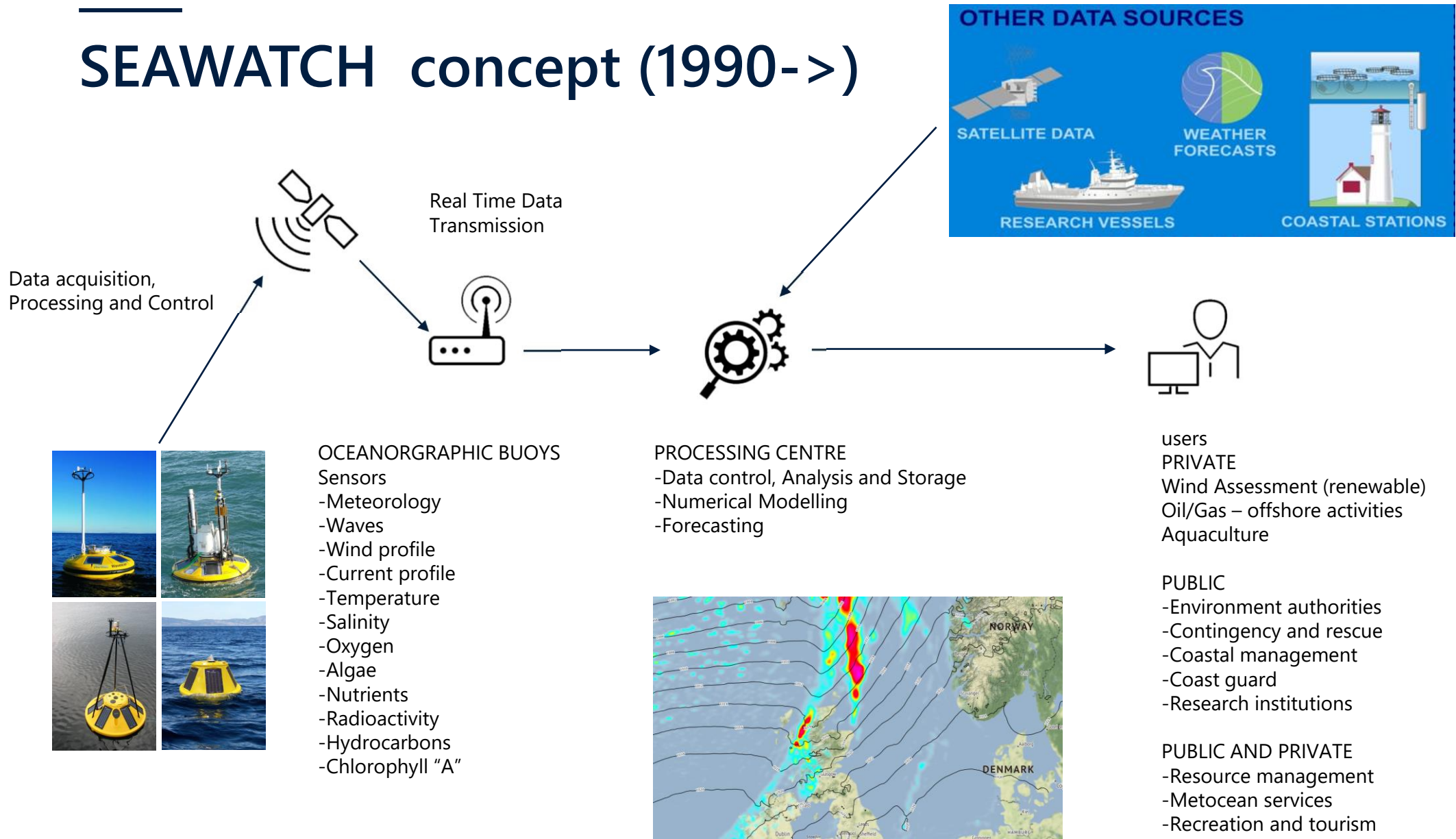


## SEAWATCH® Catamaran

Extendable platform for nearshore environmental monitoring, with easy service access of sensors.



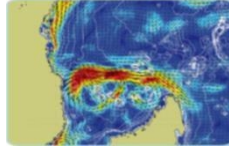
# SEAWATCH concept (1990->)



# SEAWATCH – Applications

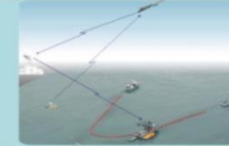


**Renewable Energy**



**Weather forecasting**

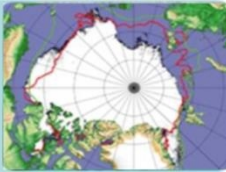
**Contingency.** Providing data for tsunami forecasting, oil spill, nuclear waste



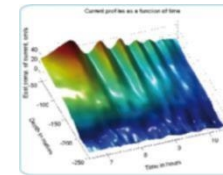
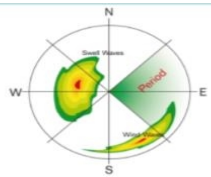
**Harbour and vessel traffic**



Acquisition of long term data for **climate studies**



**Design data** for offshore developments coastal engineering/ infrastructure



**R&D Studies** of oceanographic/ meteorological processes

Real time data during operations



**Monitoring of water quality** from pollution sources such as oil terminals and industry plants)





# SEAWATCH Wind LiDAR Buoy

Quantifying the wind resource at project specific locations is a key requirement to securing development funding and de-risking the investment

The SEAWATCH Wind LiDAR Buoy is a cost-effective and reliable solution measuring wind speed and direction profiles, waves, current profiles and additional parameters simultaneously.



Supports operational limits related to assessment, construction and offshore operations



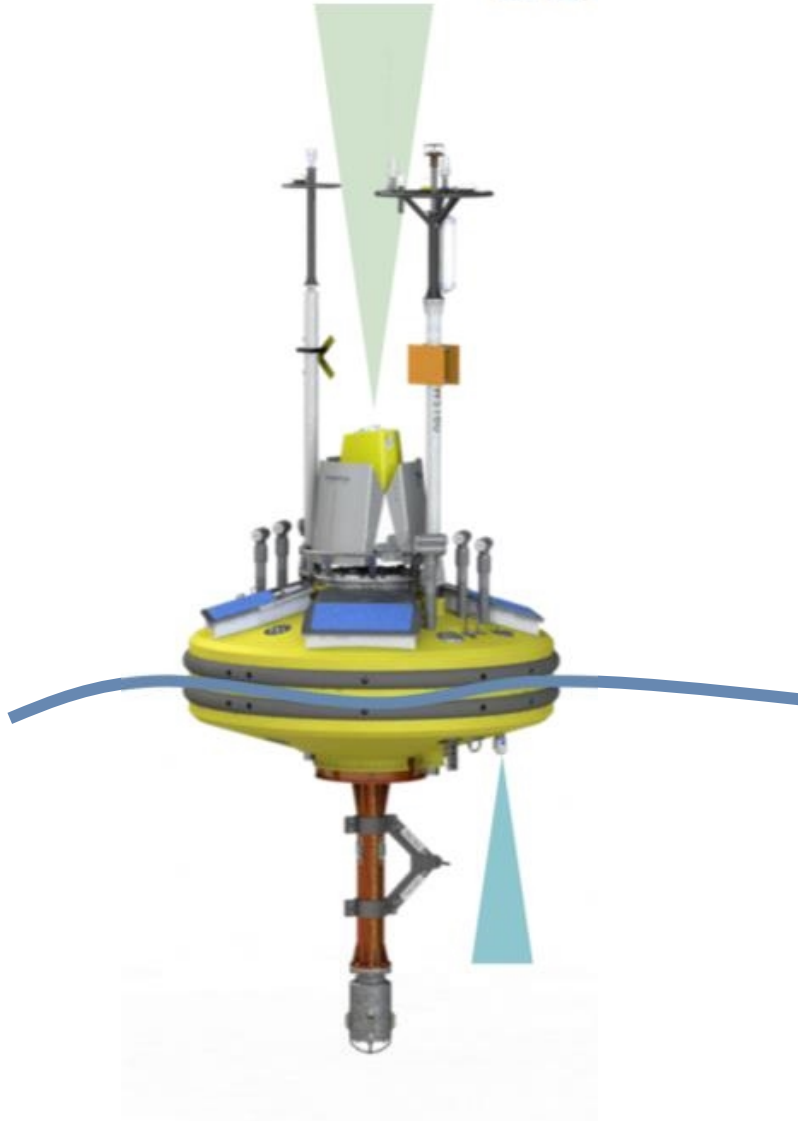
Lower costs through reduced uncertainty



Cost effective commissioning, operation and decommissioning



# Seawatch Wind LiDAR Buoy (Stage 3)

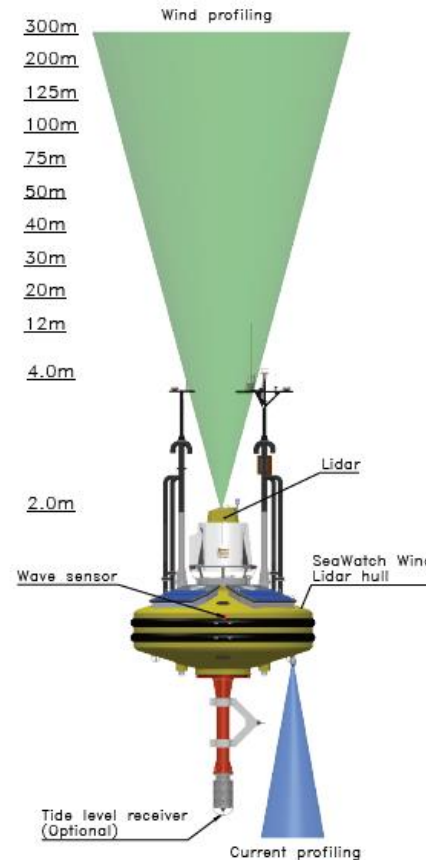


- Dimensions 3 meter in diameter, 7 meter in height, weight 2.2 tons
- Measurement (typical)
  - Standard Met (Temp., Humidity, Pressure & Wind)
  - Wind profile (speed, direction, turbulence 10-300 m)
  - Current profile
  - Waves (height, direction, period)
  - Water level (Both with depth sensor or GNSS)
- Optional
  - CT (Conductivity / Temperature / Salinity)
  - Turbidity
  - Underwater noise
  - Birds and bats monitoring
- Unified datalogging, telemetry and control system
- Power system: Long autonomy (9 months SWLB 2.x, >12 months SWLB 3.0)
- Communication – “Live feed” & “Remote access”
  - GSM / 4G
  - Iridium
  - Inmarsat / IsatDataPro
  - Wifi

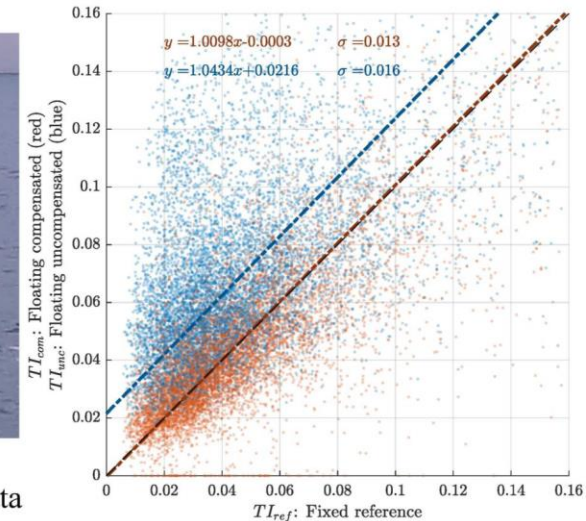
# Turbulence Intensity

## Turbulence

- *Mean wind velocity*
  - Negligible affect from buoy motion
- *Turbulency intensity*
  - Overestimated due to buoy motion.
- Software based motion compensation leads to results comparable to fixed lidar from floating systems.



- Line-of-sight lidar data
- 6 degrees of freedom
- Experimental validation
- Turbulence intensity



<https://www.mdpi.com/2072-4292/12/5/898>



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# Seawatch Wind LiDAR Buoy 3.0

- Latest generation of our LiDAR buoy.
- Trial 6-month deployment completed in October 2021
- Production started from late Q4

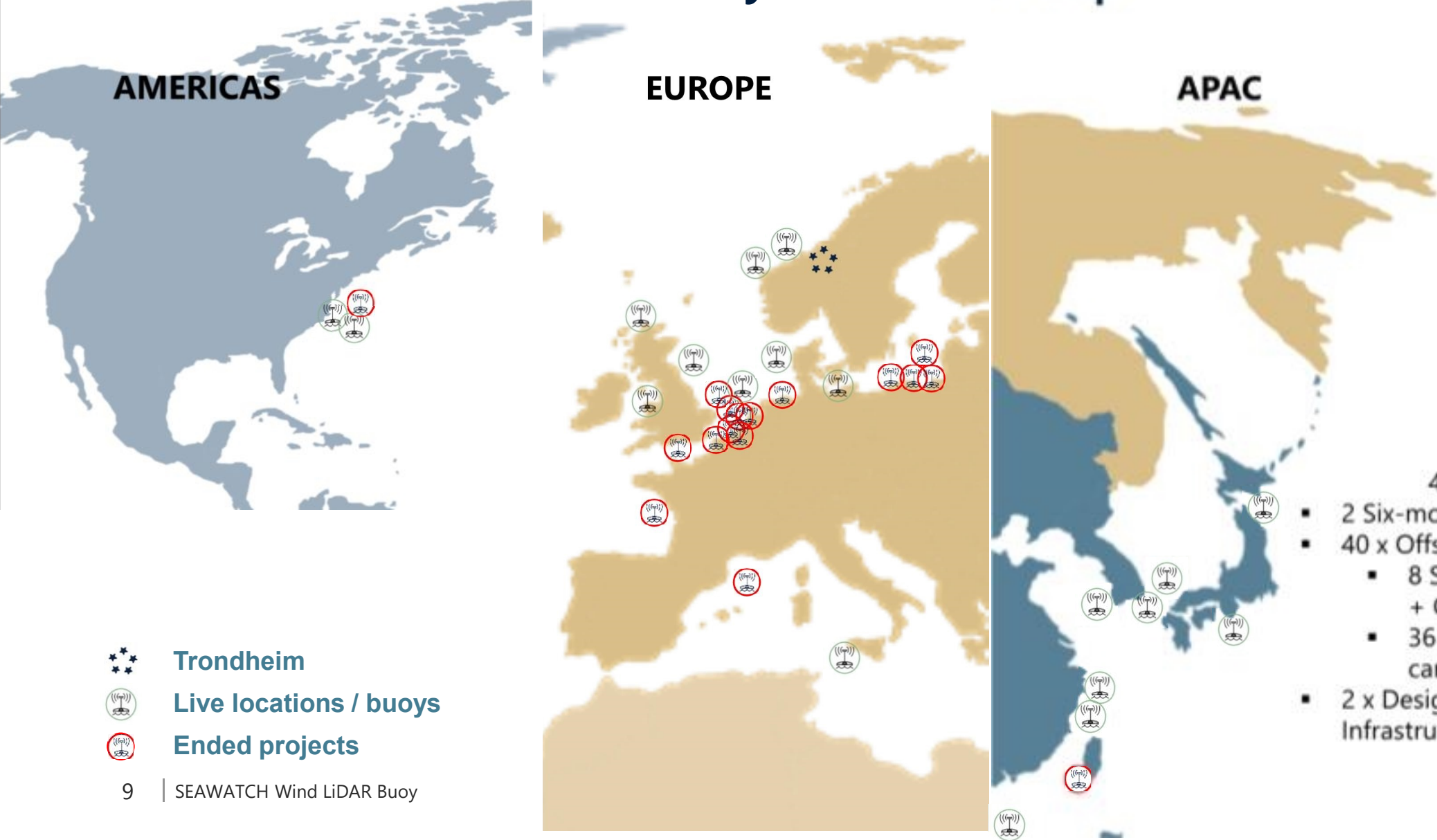
## Key elements

- Complete new casting mold
- Increase quality, robustness and easier production
- Reduce lead time for new buoys with 40%
- Power system for 13 months operation





# Seawatch Wind LiDAR Buoy – Historic map



- 48 SWLB projects:
- 2 Six-months validation trial
- 40 x Offshore Wind Market:
  - 8 SWLB Procurement contracts + O&M service
  - 36 SWLB Measurement campaigns - Data as a service
- 2 x Design Engineering & Infrastructure

☆☆☆ Trondheim  
((L)) Live locations / buoys  
((L)) Ended projects



# Track record

**FUGRO**

**FUGRO NORWAY AS**  
SEAWATCH Wind LiDAR Buoy Project Reference List

Nr.	Project	Country	Client	Period
1	Eneco	The Netherlands	ENECCO	2013
2	MODEC Floating windmill	Japan	Fugro Japan	2013
3	Ijmuiden offshore met mast-SWLB Trial validation	The Netherlands	ENECCO	11.04 – 27.10.2014
4	Wisting Field, Barents Sea	Norway	OMV (Norge) AS	15.10.14 – 31.05.15
5	Navitus Bay	UK	Navitus Bay Ltd (Eneco & EDF)	09.02.2015 – 26.12.2015
6	EACNE-SWLB validation	UK	Carbon Trust	27.11.2015-06.07.2016
7	Borsele Lot 1	The Netherlands	RVO.nl	Two buoys: 11.06.2015 – 01.03.2017
8	Borsele Lot 2	The Netherlands	RVO.nl	Two buoys: 12.02 – 22.06.2016
9	Borsele Lot 1	The Netherlands	Blauwind and Ørsted	01.03.2017 – 01.2018
10	Hollandse Kust (zuid) A&B	The Netherlands	RVO.nl	Two buoys: 04.06.2016 – 06.06.2018
11	Baltik II	Poland	Polenergia	14.01.2017 – 14.01.2019
12	Hollandse Kust (noord) A&B	The Netherlands	RVO.nl	Two buoys: 08&09.04.2017 – 10.04.2019
13	East Anglia THREE	UK	East Anglia THREE (Scottish Power/ Iberdrola)	12.05.2017 – 12.05.2018
14	Hornssea 3	UK	Ørsted	Two buoys: 3/4.07.2017 – 4.10.2018
15	Ferme Eolienne Flotante de Groix & Belle Ile	France	EOLPI	20.09.2017 – 31.03.2019
16	Yulin OWF	Taiwan	Wpd / InfraVest	12.2017 – 01.2018
17	EFGL	France	Ocean Winds (former EDPR / ENGIE)	24.05.2018 – 25.05.2020
18	Vineyard Wind	USA	Iberdrola / CIP	23.05.2018 – 14.06.2020
19	Tsugaru Bay	Japan	JWD Co., Ltd	Confidential
20	Mutsu Bay	Japan	JWD Co., Ltd	Confidential
21	M1 KF Wind	South Korea	Korea Floating Wind, Power <b>Co.Ltd</b> (Aker Solutions AS, Ocean Winds & KFWind)	01.10.2020 - ongoing
22	FEW Baltic I	Poland	RWE/ BTI Sp. z o.o.	18.01.2019 – 30.06.2020
23	Baltic Power	Poland	MEWO SA and Maritime Institute in Gdansk	24.01.2019 - ongoing
24	E39	Norway	Statens Vegvesen	07.08.2019 - ongoing
25	Hollandse Kust (west) A&B	The Netherlands	RVO.nl	Two buoys: 5/10.02.2019 – 11.02.2021
26	Ten Noorden van de Wageningen	The Netherlands	RVO.nl	Two buoys: 19.06.2019 – 20.06.2021
27	B-Wind and C-Wind	Poland	Ocean Winds	16.07.2019 – 16.07.2021
28	South Korea	South Korea	Shell International Exploration and Production B.V.	17.10.2020- 17.10.2021
29	Confidential	Japan	Pacifico Energy KK	Confidential
30	Confidential	Japan	Pacifico Energy KK	Confidential
31	Mayflower Wind Energy LLC	USA	Shell New Energies US LLC/ Ocean Winds	15.11.2019 - ongoing
32	Atlantic Shores Offshore Wind	USA	Shell New Energies US LLC/EDF	29.12.2019 - ongoing
33	Moon Project	South Korea	Ørsted	Four buoys: May 2020-ongoing
34	M2 KF Wind	South Korea	Korea Floating Wind, Power <b>Co.Ltd</b> (Aker Solutions AS, Ocean Winds & KFWind)	03.10.2020 - ongoing

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SEAWATCH Wind LiDAR Buoy Project Reference List

35	EBPI	South Korea	East Blue Power Co. Ltd. (Aker Solutions AS, Ocean Winds & EBP)	21.10.2021 - ongoing
36	East Anglia TWO	UK	Scottish Power Renewable/Iberdrola	11.07.2020- 08.09.2021
37	Confidential	China	Fugro China/China Datang Corporation	Confidential
38	Confidential	China	Fugro China/Shanghai Electric	Confidential
39	Kobe University	Japan	Fugro Singapore Marine Pte.Ltd	July 2020 - ongoing
40	Confidential	Japan	JWD Co., Ltd	Confidential
41	Hannibal Offshore Windfarm	Italy	7 Seas Med S.r.l. & COP	22.07.2021 - ongoing
42	Pentland Offshore Windfarm	UK	Highland Wind Limited & COP	09.07.2021 - ongoing
42	Surf WEA	Spain	Equinor	To start Q1 2022
43	Formosa 4	Taiwan	Swincor Renewables Energy	To start 2022
44	Thang Long Wind	Vietnam	Enterprise Energy	August 2021 - ongoing
45	Elizabeth North and South OWF (Mona and Morgan)	UK	BP/EnBW	Two buoys: To start Q1 2022
46	Energy Islands LOT 1 (North Sea)	Denmark	Energinet ETransmission A/S	03.11.2021 - ongoing
47	Energy Islands LOT 2 (North Sea)	Denmark	Energinet ETransmission A/S	03.11.2021 - ongoing
48	Energy Islands LOT 3 (Baltic Sea)	Denmark	Energinet ETransmission A/S	21.11.2021 - ongoing
49	Energy Islands LOT 4 (Baltic Sea)	Denmark	Energinet ETransmission A/S	21.11.2021 - ongoing
50	Confidential	South Korea	Confidential	September 2021 - ongoing
51	Incheon	South Korea	Ocean Winds	Four buoys: January 2022 - ongoing
52	Confidential	Japan	RWE	Two buoys: 26.01.2022 - ongoing
53	Awel y Mor	UK	RWE	To start Q1 2022
54	Outer Dowsing	UK	Green Investment Group (GIG), TOTAL Energies	To start Q1-Q2 2022

<sup>9</sup> This is the period a LiDAR was operating, the project started 22<sup>nd</sup> May 2014 without LiDAR for measuring other parameters.

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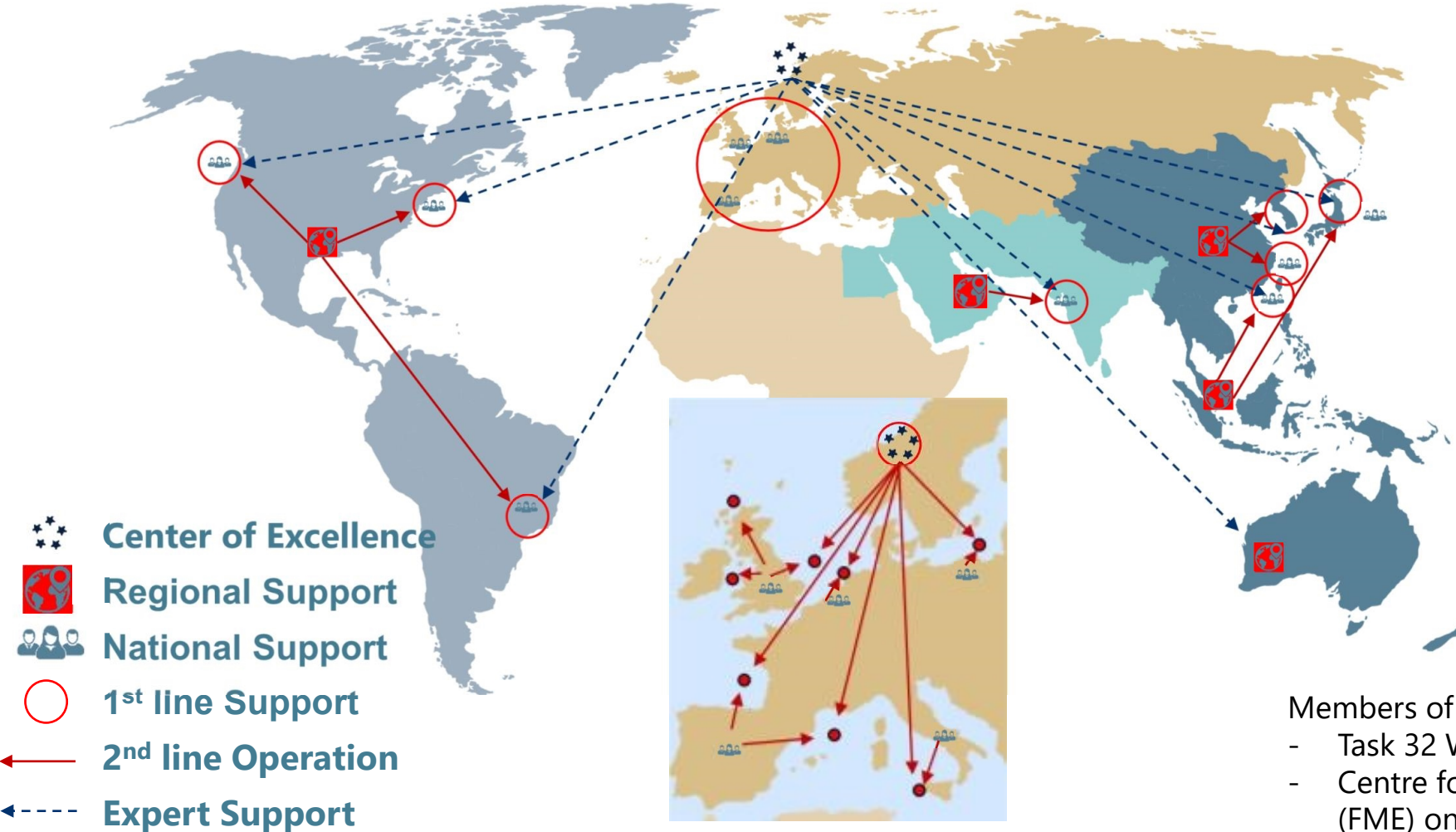
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# SEAWATCH Wind LiDAR Buoy Equipment Pool

- Fugro owns 45 lidar buoys, growing to 60+ at end of Q3.
- Global and central equipment pool, operated from Norway
- Also support client owned buoys
- Local offshore validation site, DNV approved, at Titran Frøya
- Connected to service and production facility, with Supply Chain Management
- Established Center of Excellence



# SEAWATCH Wind LiDAR Buoy Global Business



-  **Center of Excellence**
-  **Regional Support**
-  **National Support**
-  **1<sup>st</sup> line Support**
-  **2<sup>nd</sup> line Operation**
-  **Expert Support**

## Seawatch Center of Excellence

- Central Equipment Pool
- Commercial & Operational support to regions
- Business development for key clients
- Technology development
- Establish of local hubs for operational spares

## Global business

- Commercial contract held and operated by regions with support from Center of Excellence
- Regional operations and local business development

Carbon Trust Stage 3 final classification study underway.

- Targeting Stage 3 Commercial classification by Q4 2021

## Members of:

- Task 32 Working group (IEA - RP18)
- Centre for Environment-friendly Energy Research (FME) on Wind Energy called NorthWind

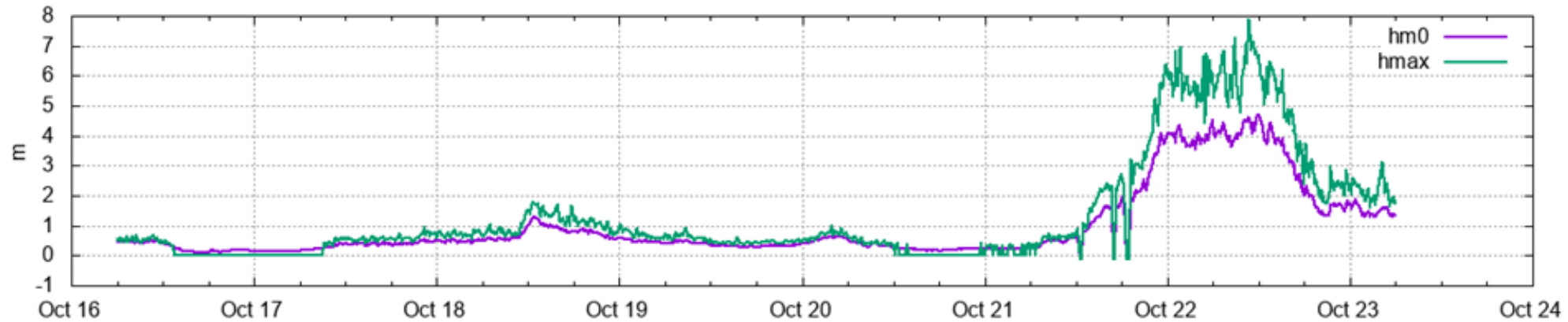
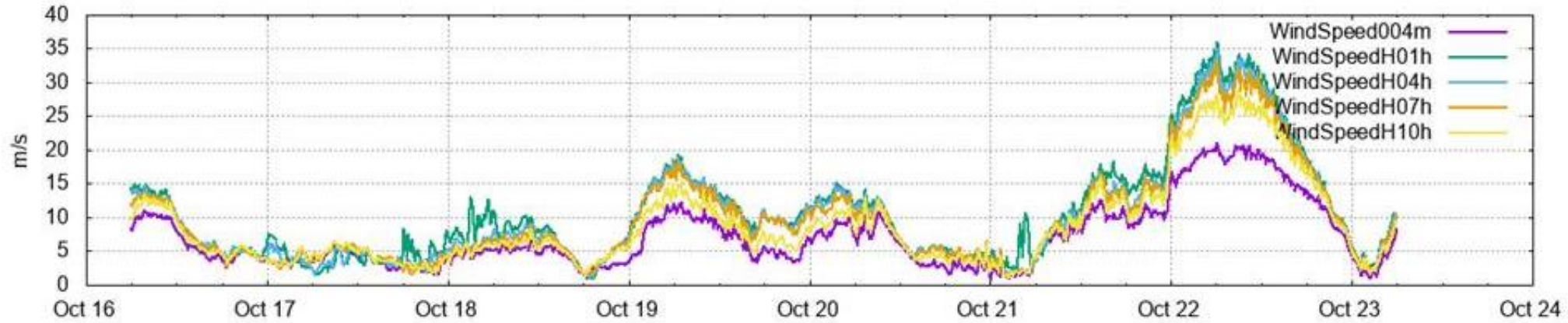




# SWLB Offshore Test site (DnV approved)– Titran (Frøya) Norway



# Weather – Frøya Test site





# O&M



- Deployment methods:
- Towing
  - Half – lift (on deck)
  - Lifting (on deck)



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and liveable world

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